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Direct telephone exchange corporation, ltd.

A technical description of the direct telephone exchange.

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A TECHNICAL DESCRIPTION

OF

The Direct Telephone Exchange

(AUTOMATIC SYSTEM)

USED BY

THE TELEPHONE
CONSTRUCTION
COMPANY,
LIMITED.

Offices and Exhibition:

84-85-86, WINCHESTER HOUSE,
OLD BROAD STREET,
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THE AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

During the past few months in which this system has been on exhibition in London, the Company has had many requests for a technical and detailed description of the apparatus.

Various Electrical Journals have contained articles descriptive of the system; but these being necessarily condensed do not give the reader as complete an idea of the mechanism as is desirable.

For this reason, a description, with a number of drawings, has been prepared, from which the reader will be able to comprehend the subject in all essentials; the mechanical details, however, can be best understood by seeing the mechanism in operation.

In order to make the description as brief as possible we will describe the small 100 system in detail, and the larger systems only in a general way.

The system, as the name implies, is entirely automatic, each subscriber being his own operator; the machine at Central does the work of the telephone girl, but is controlled by the subscriber at his telephone, thus eliminating the many annoyances with which every telephone user is familiar.

The principal advantages are as follow:—

1st.—Any subscriber can at any time, whether by day or night, call up any other subscriber, simply by operating the dial D on the front of his telephone and ringing his bell (see Fig. 1). The time occupied in making such a call is from three to five seconds.

2nd.—When any two subscribers are talking no third person can interrupt or overhear the conversation. The service is absolutely secret.

3rd.—Disconnection is automatically produced when finished talking by hanging the receiver on the hook.

4th.—Since only one man is required at the Central to look after every 1000 exchange instruments, economy in operation is obvious.

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GENERAL DESCRIPTION.

Each subscriber's telephone has two wires connecting it with the central station, thus making a complete metallic talking circuit, and also furnishing a means of operating and releasing the central mechanism to which these wires are attached. On this mechanism or switch are a number of contact points, corresponding to the number of subscribers in the exchange (this is true for small exchanges only). These contact points are embedded in plaster of Paris, and arranged in a concave form or bank, each having ten rows with ten contact points in each row, making a total of 100 (see Figs. 2 and 3, which show the arrangement of contacts in the insulating material). Each contact in a given bank is electrically connected to the same relative contact in each other bank.

Arranged vertically in the axis of this concave bank or group of banks is the shaft S (Fig. 2), having one or more radial contact arms w called "wipers." The wipers w, are bifurcated or made of two pieces of spring brass, which spread apart when passing over each contact, and thus effect a rubbing contact on both sides.

Each switch has two sets of magnets, VM and RM, with soft iron armatures, which are attached to arms U and T, and pawls p and p'. The upper set of magnets VM, acting on its arm and pawl, moves the shaft vertically, thus bringing the wiper opposite some one of the ten rows of contacts in the bank. The wiper w will now stand opposite ready to be carried by the rotation of the shaft over one of these rows. The second set of magnets RM, acting on its arm and pawl, rotates the shaft which carries the wiper w into connection with any contact in the row. In each case this step-by-step motion, which is produced by the magnets RM and VM, is taken up by the dogs d and e respectively (see Fig. 2).

When the switch is released a spiral spring attached to the lower end of the shaft rotates the wiper back over the contacts, until the dog e comes opposite the slot milled in the side of the hub vh, whereupon the shaft by its own weight drops vertically down to its normal position.

Each telephone is provided with a dial D (Fig. 1), by operating which the subscriber sends a certain number of impulses in over the two lines alternately. These impulses operate the switch, giving it first a vertical and then a rotary motion. The dial D contains ten

recesses in its edge; the subscriber places his finger in one of these recesses, and pulls it down to the stop S and lets go, when the mechanism rotates the dial back to its normal position, making a certain number of contacts. Thus to call 123, the subscriber first inserts his finger in recess No. 1 and pulls down, then 2, then 3, hundreds, tens, and units, in order. The switch at central selects and stops upon contact No. 123. Now, by ringing the bell No. 123 is notified, and answers in the usual way. If No. 123 is engaged the calling subscriber's bell will not ring, and no connection can be made until he (No. 123) has finished talking and hangs up his receiver.

A full explanation of the Telephone, with its operation and circuits, will be found on another page.

A general idea of the circuits may be had from Fig. 4, where a b c are three telephones, each connected with the central station C by a pair of wires. One wire a′ b′ c′ of each pair passes through a set of magnets m m′ m″ and all are connected by a common wire X to the positive pole of the battery B. This is the operating battery, which in exchanges of 500 to 1000 subscribers consists of not more than 50 to 75 storage cells; $\frac{1}{4}$ ampère per subscriber while calling is used in all exchanges of the 100 and 400 type. For large exchanges where the bridging system is used, only ·2 of an ampère is required. The reason for this will be given later.

The negative pole of the battery B is connected to a third wire X′ which runs to all the telephones in common. In large systems the earth is used in place of this wire, that is, X′ is connected to earth, and there is an earth connection at each telephone (see Fig. 12).

Now, subscriber b, for example, by operating the dial on his telephone, sends electrical impulses from X″ over his lines b′ and b″ alternately, and these impulses operate the magnets alternately, thus operating the switch at central and connecting the wire b″ to a″, c″, or any similar wire in the exchange. The subscriber thus calls the number desired without human aid at the central station. When the subscribers have finished their conversation, each hangs his receiver on the hook, and as the hook of subscriber b passes down, a certain combination of contacts is made which releases the switch at central station and allows it to return to its normal position, so that each can now call or be called by any other subscriber to the exchange.

Fig. 5 represents the exact arrangement of the apparatus at the exchange. Along the inside battery wire X the switches S S′ S″, etc., are arranged in rows of 25; P P′ P″, etc., represent telephones in different parts of the City, each having a tap or branch from the outside battery wire X′. The two line wires are called "units line," U, and "tens line," T; the units line in every case passes through a pair of magnets and is connected permanently to X, while the tens lines, T, etc., are arranged to connect upon occasion through a second

set of magnets with the battery wire X, as will be explained. The bank wires b are arranged in horizontal groups, directly in front of the switches, so that each has access to all of them (see explanation in another paragraph).

Each switch is provided with a private device PM (Fig. 2), which prevents anyone from interfering with or overhearing a conversation already in progress.

The exchanges are built in three sizes; the first includes the 100 and 400 systems, in which a single switch is used for each subscriber. The second and third are for 1000 and 10,000 subscribers, in both of which two switches per subscriber are used, and the magnets are bridged across the circuit; therefore the name "Bridging System" is applied. This method of placing the switch magnets across the circuit can also be applied to small exchanges, as will be explained later.

THE 100 SYSTEM.

Since the same principle and same mechanism are used in the three systems, the circuits and operation of the small 100 exchange will be traced through, and thus pave the way to larger exchanges.

The 100 system is adapted to small towns and interior exchanges where the number of subscribers is small. Each telephone is connected to the switchboard by two wires, and in addition, a third wire is run to all the telephones, as shown by X′ in Fig. 5.

Fig. 6 represents the circuits of two switches, Nos. 123 and 146, No. 123 having called No. 146. The units line U in each of the switches is permanently connected through the units magnets U to the inside battery wire X. All connecting is done on the tens lines T through the bank wires b.

The numbers used in all exchanges must be such as will fit the mechanism. In this case three motions are required to complete the circuit through the switch, therefore the numbers used must begin with 111. To call No. 111, the first impulse comes in over the units line, the second over the tens line, and the third over the units again. This switching from line to line is accomplished by mechanism in the telephone. The first and last impulse must always come in over the units line.

The mechanical part of the central switch is so arranged that the tens circuit is completed only after one impulse has been sent in over the units line, or after the units magnets have operated once, and only once. This is accomplished by means of the mechanism shown in Fig. 7. S is an end view of shaft having a small projection J: T′ is the tens line spring; T″ is the tens battery spring; a is a small arm which is raised by the action of the units armature; r is a small runner which, when resting on J, holds the springs T′ T″ in contact. Now when the shaft S is moved one notch (*i.e.*, after one impulse is sent in over the units line) the projection J engages the runner r and holds T′ T″ in contact, the projection J extends along the shaft so that a vertical motion is possible without breaking the contact at T′ T″.

If now a second impulse comes in over the units line, the projection J moves away from the runner r, and the spring T″ drops to the base of the switch which serves as a part of the talking circuit, including the shaft and wiper.

The cross connecting or bank wires, are arranged below the switches as shown in Fig. 6 and Fig. 2 at b. Each subscriber has an individual wire among these banks b, which, after it leaves the bank is called the normal wire n and n′ in Fig. 6, and is connected to the normal spring n′ on the top of the switch. When the switch is at normal, this spring is in contact with the base, but as soon as a call is made, the circuit is opened, and the subscriber has a private line so far as anyone calling him is concerned.

The Operation of the Switch is as follows:—

Referring to Fig. 6, suppose that No. 123 calls No. 146, the mechanism in telephone No. 123 first sends one impulse over the units line U, the units magnets U operate, the shaft is rotated one notch, and the tens line is completed at T′ T″ as shown in Fig. 7. Now four impulses are sent over the tens line T through T′ T″ and through the tens magnets T. The shaft is carried vertically four notches. The last six impulses are sent in over the units line, the shaft is rotated six notches, the spring T′ is raised and dropped at each impulse, see Fig. 7, but always rests on the base after a call is made, or after the switch has been released.

We now have the wiper w, Fig. 6, on contact No. 146, and the tens line spring T′ rests on the base contact. No. 123 signals No. 146 by a magneto and bell. No. 146 removes his receiver from the hook and answers in the usual way. As explained before, if the subscriber called for is engaged, the calling subscriber's bell will not ring, he must in this case hang up his receiver and make the call again in a few minutes. The fact that two subscribers are in talking connection, interferes in no way with any other subscribers who wish to use their telephones.

THE TALKING CIRCUIT.

The telephone circuits will be given later. At present it is only necessary to remember that when the receiver is on the hook the bells are in circuit, when the receiver is removed, the hook goes up and the receiver and secondary of the induction coil are in circuit. (This is called the talking circuit of the telephone.)

Now to trace the talking circuit we begin at No. 123 on the tens line T—to the tens line spring T′—to base of switch—to shaft—to wiper w—to bank contact No. 146—to bank wire b—to normal wire n′ on 146—to base—to tens line spring T′—to tens line T—to telephone No. 146,—back on units line U—to units magnets U—to common talking strip X—to units magnets U on 123—to units line, and thus complete the circuit back to telephone No. 123.

THE RELEASE.

When the conversation is ended, each subscriber hangs his receiver on the hook. The telephone that received the call takes no part in the release, but as the hook of the calling telephone passes down, a combination of contacts are made which release the switch, allowing it to fall back to its normal position.

The hook has attached to it an insulated spring S (Fig. 15), which is connected to the battery feeder. When passing down, the spring S sends first an impulse over the units line, holds this until the circuit through the tens line is completed, breaks the units and then the tens. As explained before (Fig. 7), the tens line is completed at T′ T″ when the units arm is down. In this way the two impulses are made consecutively and broken in the same order.

The release mechanism comprises a very ingenious combination of mechanical movements, which act in accordance with the electrical impulses. The mechanism is very difficult to show diagramatically, but reference to Fig. 8, A and B, will enable the reader to get the idea. Fig. A represents an end view, showing the disengaged dog d and the units arm down against the magnets. Fig. B represents a side view with the tens arm down, as the switch appears when in the act of releasing.

As the units arm comes down, a wire w which is a part of the arm, passes under another wire w′ attached to the tens pawl, the tens arm goes forward and the wire w′ being bent, as shown in Fig. B, slides over the wire w. The end of the wire w′ rises and carries with it a wire d′ which projects from the dog d, thus the dog is disengaged from the teeth, as shown in Fig. A. As the units arm falls back into position, the wire w″, which is merely a projection of w, catches under the wire d′ and thus prevents the dog d from falling back into the teeth on the hub S. After the dog d is disengaged, a spiral spring which is attached to the lower end of the shaft, rotates the latter until the dog e comes opposite the slot which is cut through the teeth on the tens hub (see Fig. 2), and the shaft drops vertically to its normal position, as explained before.

It will be seen that when the units arm moves forward again the wire d′ drops from the wire w″ and allows the dog d to fall into the teeth on the hub.

When the units arm falls back, it would appear that the tens line circuit would be broken at T′ T″, and this would be so were it not for the wire a″ which is a part of the tens arm, and serves to hold the springs T′ and T″ in contact until the circuit is broken at the telephone.

PRIVATE DEVICE.

As stated before (see page 6), each switch has a normal spring which is open when the switch has made a call; this makes the service half private.

In order to prevent two or more subscribers calling the same number, a small attachment shown in Figs. 6 and 9 is used, and effectually eliminates all trouble of this sort. The mechanical details of the device are shown in Fig. 2, where P M is the private magnet with its attached armature a, the arm a′ catches under a small insulated rod and keeps the spring T′ from touching the base contact or the spring T″, thus one side of the circuit is open.

The device is shown attached to the switch in Fig. 6; Fig. 9 shows the circuits. Since its action depends entirely on local circuits, its operation can in no way affect the conversation already in progress.

Each switch has a set of springs 1, 2, 3—Figs. 2, 6 and 9. No. 1 is connected to the inside battery wire X; No. 2 is connected to the private wiper w′ belonging to a particular switch; No. 3 is connected to the private magnet m, and this in turn is connected to the private battery wire P X, which is five cells of the main operating battery of the exchange.

A separate set of banks, represented by the line b′, Fig. 6, is used for the private attachment, the private wipers w′ are set on contacts corresponding to the position of the talking wipers w.

Now if 123 calls 146, the private wiper w′ of No. 123 makes connection with contact and bank wire No. 146 (see b′, Figs. 6 and 9), the springs 1 and 2 are in contact as shown at No. 123. If now 127 calls for 146, the private wiper w′ of No. 127 engages the same contact as that of 123, and the local circuit will be closed through the private magnet m′ of 127.

Springs Nos. 2 and 3 are brought into contact at each impulse of the units magnets. The wiper w′ makes connection with contact No. 146 just as 2 and 3 are brought into contact (*i.e.* during the time interval of the last impulse). The circuit is then completed from P X through the magnet m′ through springs 2 and 3—through w′ through bank wire b to wiper w through springs 1 and 2 at 123 and thus back to the other side of the battery. The private magnet operates and opens the circuit, as explained before (see Fig. 2).

THE BANKS.

The bank wires and contact points furnish the medium for inter-communication between subscribers, and therefore play an important part in the exchanges.

They are arranged in a horizontal position before the switches as shown in Figs. 5 and 6. The manner of furnishing a contact and holding them in position is shown in Figs. 2 and 3. The contacts are punched out of sheet brass and polished by tumbling them in an iron drum with pieces of leather, after this they are set in a mould which is made very accurately so as to hold them in an exact position, then plaster of Paris is cast in around them and allowed to set or harden. The cast with its containing contacts is placed in an oven and thoroughly dried, after this it is soaked in paraffin and clamped in a frame ready to have the wires attached. The rear end of the contacts are well tinned, and tinned wire is used to facilitate soldering. The wire is looped from a contact in one bank to a corresponding contact in the next bank, and so on through a row of fifty. When completed, pieces of insulating material are placed between the soldered ends of the different rows. The banks are then ready to be tested. The contacts are arranged in banks of 100, ten rows with ten contacts in a row. The same bank is used in all exchanges (see diagram actual size, front and side view, Fig. 3).

The bank contacts are numbered as shown below, the contact in the lower left hand corner is always No. 11, it may be 111, 211 or 911—it is numbered thus because one vertical and one rotary movement must be imparted to the shaft in order that the wiper may rest on this contact.

101 102 103 104 105 106 107 108 109 100
191
181
171
161
151
141 etc.
131 132
121 122 123 124 125 etc.
111 112 113 114 115 116 117 118 119 110

It might be mentioned here that the figure o used makes "ten" contacts, so that the numbers in each bank will begin with 111 in the lower left hand figure, and end with 100 or 1xx in the upper right hand figure, as shown above.

THE TIME FUSE.

Small fuses and lightning arresters are placed in each line to protect them in the usual way. In addition to this, a time fuse is inserted in each line wire or in the battery line of each switch to protect it from stray currents, or a short circuit with the calling battery in case a line wire finds accidental earth. The fuse is shown in Fig. 10, where r is a small pencil of hard rubber wrapped with one layer of German silver wire. S and S′ are springs in circuit: g is a stop which catches the spring S′ when it is released.

If, for either of the above reasons a continuous current be caused to flow through the fuse for a short time, say half a minute, the heat produced in the German silver wire will cause the pencil r to expand, and thus push the spring S up until the circuit is broken at c. When the spring S′ is released, it flies out and closes a local circuit at g; in this circuit is a buzzer P, which gives warning of the fault. By pressing a series of break-circuit buttons on the board the fuse can be located at once.

For small exchanges one of these fuses is placed on the back of the board in the battery circuit of each switch, but for large exchanges it is preferable to have them on the distributing board one in each line.

A special distributing board on which are placed the time fuse, a special carbon lightning arrester, the line fuses and test switches, is designed for the system.

CONCLUSIONS FOR 100 SYSTEM.

Thus we have described the circuits and operation of a small system capable of accommodating 100 subscribers. This type of switch, with a few changes, is also used for exchanges of the 400 type.

All switch parts for exchanges of larger capacity are exactly like those shown in Fig. 2.

THE 400 SYSTEM.

The switch used in the 400 system differs very little from that of the 100 system which has just been described.

Four banks, or 400 contacts, are placed on each switch. The first or upper bank will contain the contacts for numbers in the "one hundreds," the second will be for the "two hundreds," etc. All numbers used will be in the 100's, 200's, 300's or 400's. There are four insulated wipers on the shaft, one for each bank. The rotary hub rotates loosely on the shaft, and carries with it an auxiliary switching device, or selector, on which are four insulated points, each of which is connected to one of the four wipers. Now, when a call is made, the first set of impulses sent in over the units line rotates this loose hub, selecting one of the wipers and thus putting it into electrical connection with the tens line. The second set of impulses come in over the tens line, the rotary hub is locked to the shaft and the whole is carried vertically. The third set of impulses come in over the units line, the hub and shaft are rotated together, and the four wipers are brought into connection with the contacts in their respective banks; but only the one selected, as above explained, is in electrical circuit.

The release and all switch parts are the same as those used in the 100 system.

THE BRIDGING SYSTEM.

In the apparatus described thus far the electro magnets actuating the switches are included in the circuit when conversation is going on, and are consequently given a low ohmic resistance. This method answers very well for small interior or private exchanges, but can not be applied to exchanges connecting thousands of lines.

The larger capacity exchanges, *i.e.*, those for 1000 or 10,000 subscribers, are equipped with what is termed the "bridging system." The working principle and the mechanism are the same as that described above, but the circuits are slightly different, a system of junction wires being employed in the exchange which gives every subscriber access to all other subscribers without requiring such a large number of wires as might have been expected in such a system. The advantages of this bridging system are that the operating magnets for working the instruments, being connected across the circuit, maintain a balanced circuit, and not being talked through, can be of high resistance, or about 300 ohms. The working current is, in consequence, only about 0·2 ampère, and it is possible to operate over long lines using the earth as the return in the calling circuit, but the second wire of the line as return when talking; the line construction is, therefore, similar to that used in metallic circuit systems.

Fig. 11 shows the talking circuits of the small system; the switch magnets m and m′ are in one side of the circuit, while a small retardation coil R is placed in the other side, so as to balance the circuit as near as possible.

Fig. 12 diagramatically shows the talking circuits of the bridging system. P and P′ are two telephones connected by a metallic circuit, which is bridged by the two pairs of magnets mm′ in series. TT′ indicate two similar telephones whose mechanisms are at different positions of the exchange switchboard; the operating battery, one pole of which is put to earth, is shown at B.

In this system two sets of mechanism or switches are used in the exchange for each subscriber. For convenience these switches are called "selectors" and "connectors." The first enables him to select the hundreds, or the thousands and hundreds, as the case may be, of the subscriber's number he wishes to call up; by the second instrument he selects the tens and units of the number wished for. For the 1000 subscriber system the numbers range from "000" to "999," and for the 10,000 system from "0000" to "9999," so that in the 1000 system three motions, and in the 10,000 system four motions are necessary to call up a number required.

In a 1000 system the selectors are arranged in sections of 10 selectors each. Each section gives access to 10 connectors—one for each hundred up to 1000, thus making a possible $10 \times 100 = 1000$ connections. Fig. 13 is a skeleton diagram of the circuits for one such section, with its ten corresponding connectors.

Each selector, SS′, etc., has access to ten circuits, b, and each of these circuits leads to a connector switch, 1, 1, 1, etc.; each of these connector switches is given the same number as the section to which it belongs, and it has access to 100 pairs of talking circuits, b′, b″, b‴, etc., which are taps from the subscribers' line wires, as shown at N. As an example, if telephone P wishes to call P′ (No. 901), the switch S first selects the ninth circuit of the wires b, then the connector C″ selects the first circuit of the wires bb; the circuit is now complete through the wires N between P and P′.

The system of grouping in the 10,000 system is similar in principle to that in the 1000 system just described; in the 10,000 system, however, the selectors are arranged in 100 sections of 100 each, and each group has access to 100 connectors—one for each 100 in 10,000—thus giving a possible 10,000 connections.

Fig. 14 shows a diagram of the circuits of one such group, with a part of the attached connectors. In either system the talking circuits are completely metallic, the lines 1, 2, 3, etc., in the diagrams representing a double wire. In the exchange itself the longest connecting wires (*i.e.*, the bank wires) are 36 ft., and these are not connected with anything but individual line wires until a call is made. The fact that all bank wires are arranged in groups, each of which has a certain definite number corresponding to the subscriber's number which it represents, makes the matter of exchange testing very simple.

A complete system of tests is made by one operation at the central office in such a way as to detect a fault in any part of the exchange wiring or the line construction. To describe these in a comprehensive manner would require more space than we wish to give in this pamphlet, therefore they will be omitted.

In cases where it is desired to talk through a small private exchange, over trunk lines, a system of "bridging" is also adopted. The same low resistance switch magnets are used, and in addition a special form of retardation coil, having an armature and two windings, is placed in the battery circuit of each switch. The first winding is of low resistance and is in circuit at all times. The second winding has a resistance of 1000 ohms, which is cut out by the action of the armature when the inner coil is energised. Thus when the calling operation is taking place the 1000 ohms coil is cut out of circuit at each impulse, allowing a comparatively heavy current to pass through the switch magnets; but when a call is finished, the coil of the calling subscriber and that of the called subscriber are bridged across the talking circuit in series with the switch magnets, thus making a bridge of over 2000 ohms.

The method of "bridging" can also be adopted to large systems.

THE TELEPHONE.

As stated before, each subscriber has control of his own service. By operating the dial shown in Fig. 1, he makes the desired connection. He then signals by means of a magneto generator, and when finished talking, automatically disconnects by placing his receiver on the hook.

In addition to the regular receiver, transmitter, induction coil, magneto-generator, and polarised bells, that are necessary parts to any exchange telephone, the automatic has the dial or calling device referred to above. The action of this device depends on the well known principle, used in all messenger and police call systems. The operation of the dial winds up a spring which, as it runs down rotates a toothed wheel, thus determining the number of contacts or current impulses sent in for each movement of the dial. A small friction governor retards the motion of the dial so as to make the contacts even. The speed of the dial depends on the tension of the spring which is adjustable. As a preliminary to ringing a correspondent in the usual way, the subscriber originating the call must effect the connection at the exchange between his circuit and that of his correspondent by operating the keyboard of his apparatus. This is effected by inserting the tip of the finger into a hole in the dial (seen in the figure) corresponding to the number required, and pulling the dial round to the stop, when, on being released, it returns to zero automatically. This operation is repeated for each figure contained in a concrete number representing the subscriber wanted, who is subsequently rung by the magneto-generator in the usual way.

TELEPHONE PARTS.

There are Six distinct Circuits in the Telephone.

With the hook down.

1st. Circuit for receiving rings.

With the hook up.

2nd. The calling circuit.
3rd. The ringing circuit.
4th. The talking circuit.
5th. The local battery circuit.
6th. The release battery circuit.

Fig. 15 represents the circuits and parts as follows :—

I. Induction coil.
Tr. Transmitter.
P. Receiver.
M. Magneto-generator.
B. Local battery.
F. The keyboard frame, which is always in circuit with the hook H., battery spring K, and wheel W. The latter makes contact alternately with the line springs U and T.

b. The battery switch is closed at the first motion of the dial, and is held open when the hook is down.
b′. Is the platinum contact point for the battery impulses.
U′ T′. The units and tens release springs.
S. The battery release spring insulated from the hook.
t. Talking circuit open when the hook is down.
t′. Also talking circuit opened at each motion of the dial, thus cutting out the receiver when calling.

The circuits may be traced as follows :—

1st. Receiving rings.

When the hook is down, the circuits are as shown in the figure; the ringers R are in circuit. Beginning at the units line we pass—to the spring U—to W - to F—to H—to R, and through R out on the tens line.

Now with the hook up we have—

2nd. Calling Circuit.

The first motion of the dial closes the battery switch b; the spring U is still in contact with the wheel W as the dial rotates back the toothed wheel mentioned before, causes the spring K to make contact with b′ a certain number of times.

The current comes from earth or the battery feeder through b—to b′—to K—to F to W—to U, and thus out on the units line to the exchange.

The next motion of the dial brings the wheel W in contact with the spring T, and as the dial rotates back the impulses pass out over the tens line.

The talking circuit is broken at t′ at each motion of the dial, as the dial and mechanism rotates back to its normal position this contact is closed again, not however, until after the last battery impulse is sent over the line. If a third motion of the dial is made the spring U will again be in circuit, and if a fourth be made the spring T will be in circuit, thus the impulses are sent alternately first over one line, and then over the other.

The only difference in the telephone mechanism for large or small exchanges is the number of pins in the wheel W: thus for all exchanges up to 1000 three motions only are necessary. If a fourth be made, neither of the springs will be in contact with W; thus if a subscriber calls a number and then calls another without releasing from the first, the springs U and T make no contact, and he gets an open circuit. The same applies to large exchanges where four motions are used, a fifth motion will throw the telephone out of circuit, and no call can be made until the receiver has been placed on the hook and removed again.

3rd. Ringing Circuit.

After the call is complete the subscriber sends his signal. When the magneto is used the handle slides in automatically, thus opening the talking circuit at C and closing the magneto circuit at C′.

Beginning at the units line we pass to U—to W to F—to t—to t′—to C—to M—to R, and thus out on the tens line.

4th. Talking Circuit.

When the handle of the magneto assumes its normal position, the talking circuit closes at C.

Beginning at the units line we pass to U—to W—to F—to t′ to t—to C—to P—to I, and thus out on the tens line.

5th. Local Battery Circuit.

The local battery circuit includes the battery B, the switch l, the primary of the coil I, and the transmitter T.

6th. The Release Circuit.

As the hook passes down it first breaks the talking circuit at t: the release spring S then makes contact with the units spring U′, this sends a current ont over the units line. While this is held the spring S also makes contact with the tens spring T, then the units contact is broken, and an instant after the tens is broken; these current impulses release the switch as explained before, see Fig. 8.

When the hook has reached the position shown in Fig. 15, the battery circuit is broken at b, the local battery at l, and the circuit for receiving rings is closed at R, the wheel W flies back, so the spring U is on the first pin of the wheel W, as shown in the figure.

The talking apparatus consists of the transmitter, the induction coil, the local battery, and the receiver.

The transmitter is of the Hunnings type. Being of a special design and careful construction, it can be used on trunk lines. On the wall instruments an adjustable arm is used, so as to give the transmitter seven inches variation in height.

The induction coil is larger than those generally used. The primary coil measures ·5 ohms, and the secondary about 40 ohms.

The local battery consists of two wet cells; dry cells may be used if preferred. Any type of double or single pole receiver may be used.

The Telephones are made in several different styles:

1st. The Wall Set.

Which is provided with an adjustable transmitter arm, and a writing shelf.

2nd. The Cabinet Set.

In which the telephone parts are placed on a fancy desk, to be used in private offices, or in soundproof cabinets, for trunk line service.

3rd. The Desk Set.

In which the calling and signalling devices are placed in a small ornamental case which may be moved about on a desk. A long flexible cord and a combined transmitter and receiver are used on this set.

LOCATION, FLOOR SPACE, ARRANGEMENT, ETC.

The exchange-room should be well lighted, and in a fireproof building if possible; a top floor is preferable so as to avoid dust; the room should be kept very clean and perfectly dry. However all parts of the mechanism are nickel plated so they do not oxidise easily.

The selectors for a 1000 exchange are arranged in rows of 30—three sections in a row. Six of these rows are placed on a frame or board. This board or frame is 11ft. long, 7ft. high and 1ft. wide; adding 2ft. for space between the boards, each 180 selectors will require a floor space of 11 × 3ft.

The connectors are arranged in rows of twenty-five, six of these rows are placed on one board. These boards are 9ft. long, 7ft. high and 1ft. wide; adding 2ft. for space, each board of 150 connectors will require a floor space of 9×3ft.

Fig. 16 is a plan for a complete 1000 exchange. The selectors S S S, etc., are arranged on six boards, five of which carry 180 switches, and one, S′, has space for the remaining 100. The connectors C C C, etc., are arranged on seven boards with space for 150 each. At the end of the boards a space of 2ft. is left, and in the centre of the room there is a passage 6ft. wide.

The distributing board D occupies a space 25ft. long by 8in. deep, and is placed 2½ft. from the wall, so that a room 50 × 17ft. is large enough for an exchange of 1000. In addition to this a small battery and supply room would be required.

The selectors for a 10,000 system are arranged in rows of twenty-five. Eight of these rows, or 200 switches, are placed on one board. This board is 9ft. long, 8ft. high and 1ft. wide; adding to this 2ft. for a passage between the boards, we have a space 9 × 3 ft. required for each 200 selectors. The connectors require the same amount of space.

Fig. 17 is a floor plan for a 5000 exchange. The selectors S S S, etc., are arranged on twenty-six boards, and the connectors on the same number; leaving an end passage of 2ft. between the different boards, and a passage 5ft. wide in the centre, we have a room 40 × 45 ft. large enough for a 5000 exchange, Additional space is required for the distributing board, batteries, etc.

A FEW POINTS.

The patents covering this system are those granted to A. E. Keith and John and Charles Erricson, also several less important ones that have been bought up.

Thirty of these exchanges are now operating in the U.S.

Two other automatic systems have been proposed :—

The Callendar, a Canadian invention, and the Apostoloff, a Russian invention ; neither of these systems have been even experimentally able to work more than a small number of phones, so that neither of them can in any sense compete with nor even compare with this system.

This Automatic Telephone Exchange, so far, has not been used in any part of Europe. The exhibit now at 84, Winchester House, London, E.C., is the first and only exhibit of this type that has ever been on this side of the Atlantic.

The German Postmaster-General is causing 400 to be installed in the Berlin telephone system.

The line construction is the same as that used at present, *i.e.*, two wires for each subscriber. The system can be attached to old iron or phosphor bronze wires, but No. 14 hard drawn copper is now considered to be the best.

The exchange apparatus costs about the same as the old system ; the great point of advantage is the saving of operating force, one mechanician only being required for every 1000 subscribers. A chief electrician and superintendent are, of course, required in very large exchanges.

The total number of soldered connections that must be made on installing a 1000 exchange is 10,000. The total number for a 5000 exchange is 92,400. The soldered connections on the banks are made at the factory and are included in the cost price of the switch.

Any form of battery may be used for operating the switches, but accumulators are preferred.

All switch parts are exact duplicates of each other, so if the mechanician acquaints himself with one switch he knows them all.

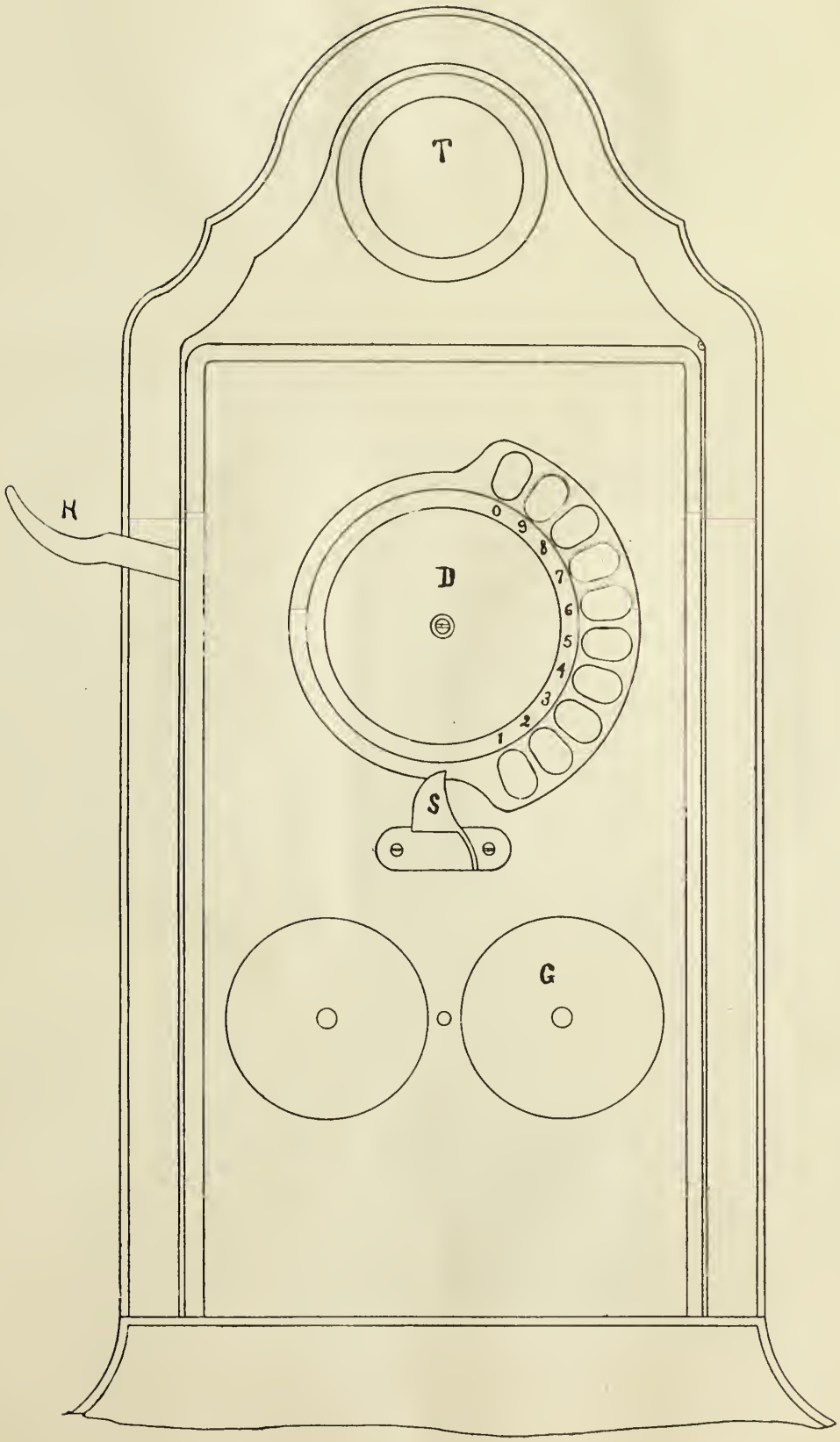
Trunk connections can be made automatically, but it is preferable to use an operator, so as to keep account of the toll, and to limit the conversations. The trunk line running to a given town is numbered, a subscriber wishing to talk to this particular town calls a given number and rings his bell, this action causes a shutter to fall, the operator answers, and makes the connection in the usual way.

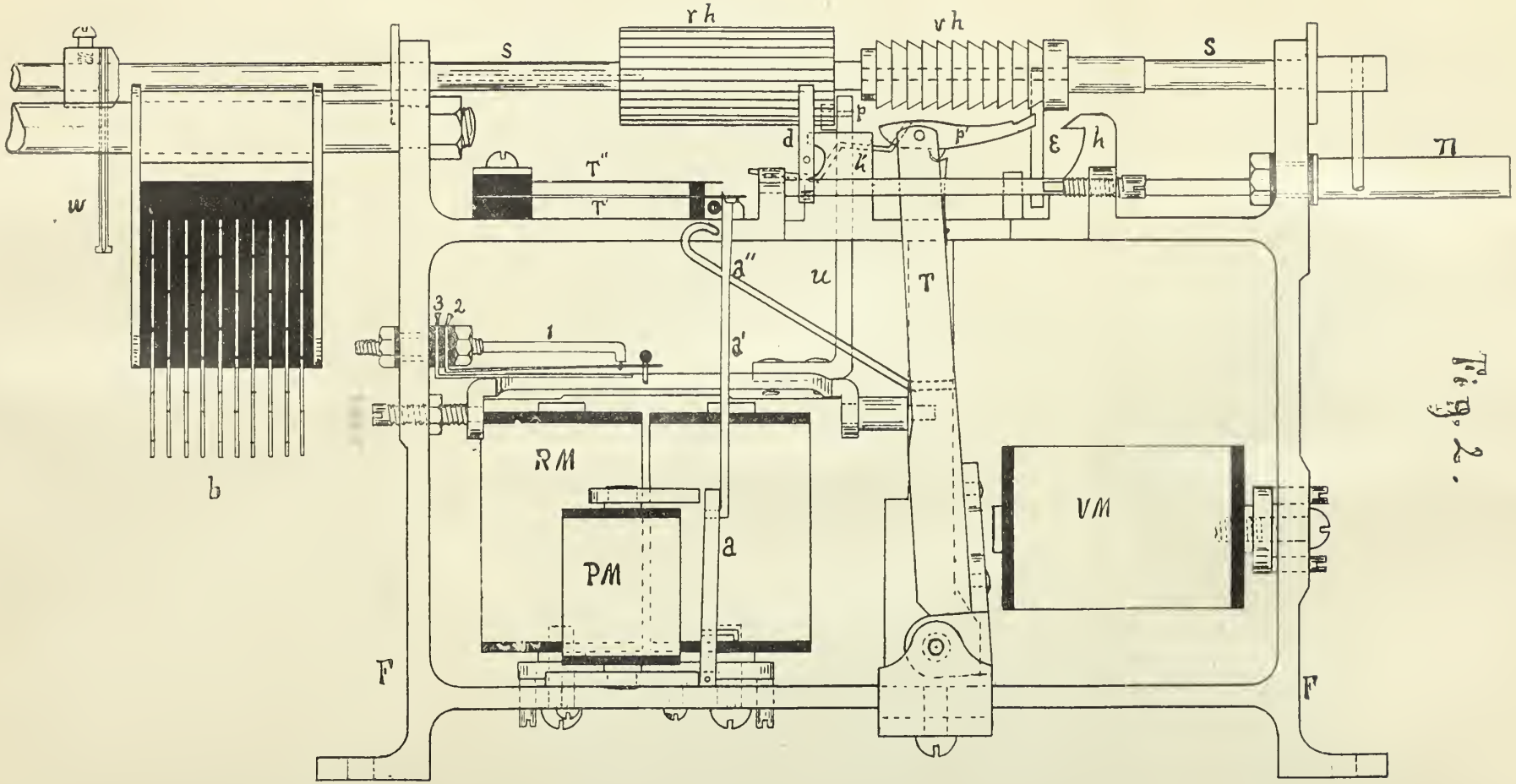
The system is quite applicable to small interior or private exchanges; many such are now working in America. Among others are the White House, Washington, D.C., and several other government buildings.

By disconnecting the private attachment on a particular number, all subscribers can call this number, and thus listen to an entertainment or news of any kind spoken at one telephone. Other special services can be given, such as private calls, penny in the slot telephone, etc.

Two or more telephones may be placed on one line: thus, if two telephones are required in the same establishment they may be attached to the same line leading to the exchange; calls can be sent or received from either of them, and at normal, the two instruments may be used as a private line, without passing through the central.

Fig. 1.





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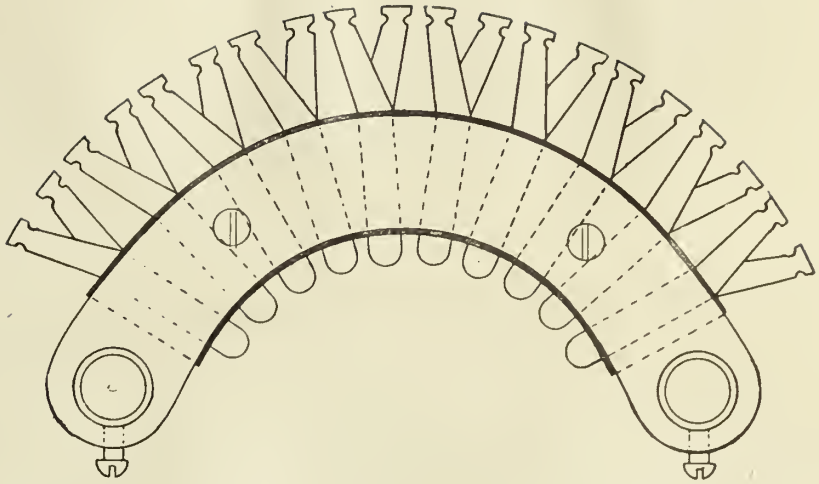
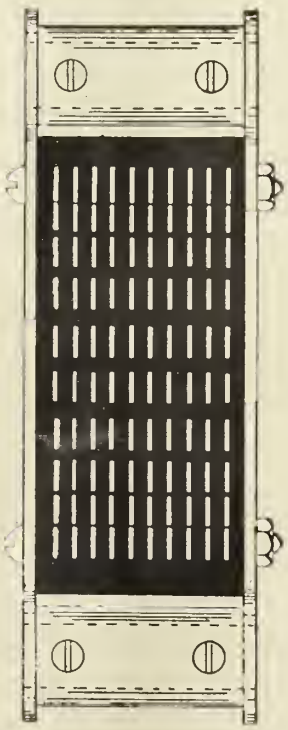
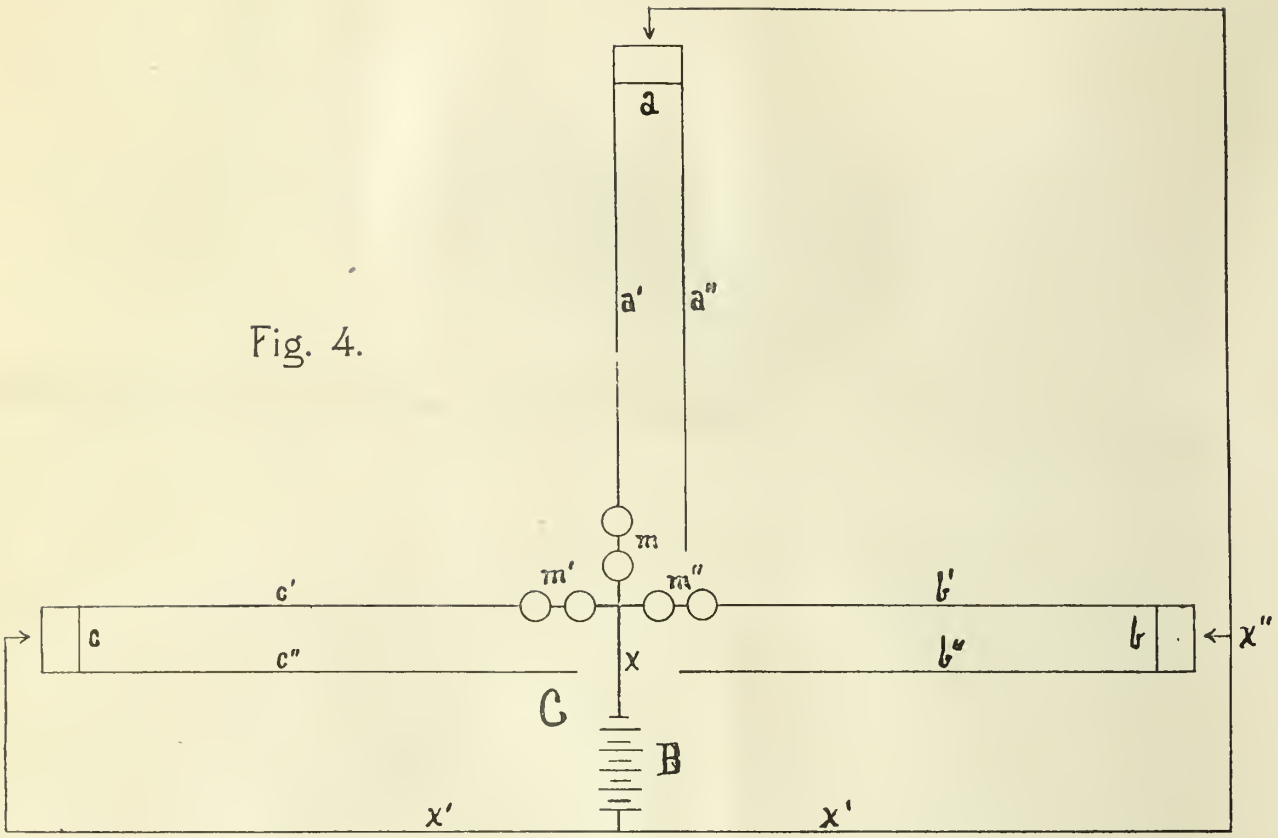
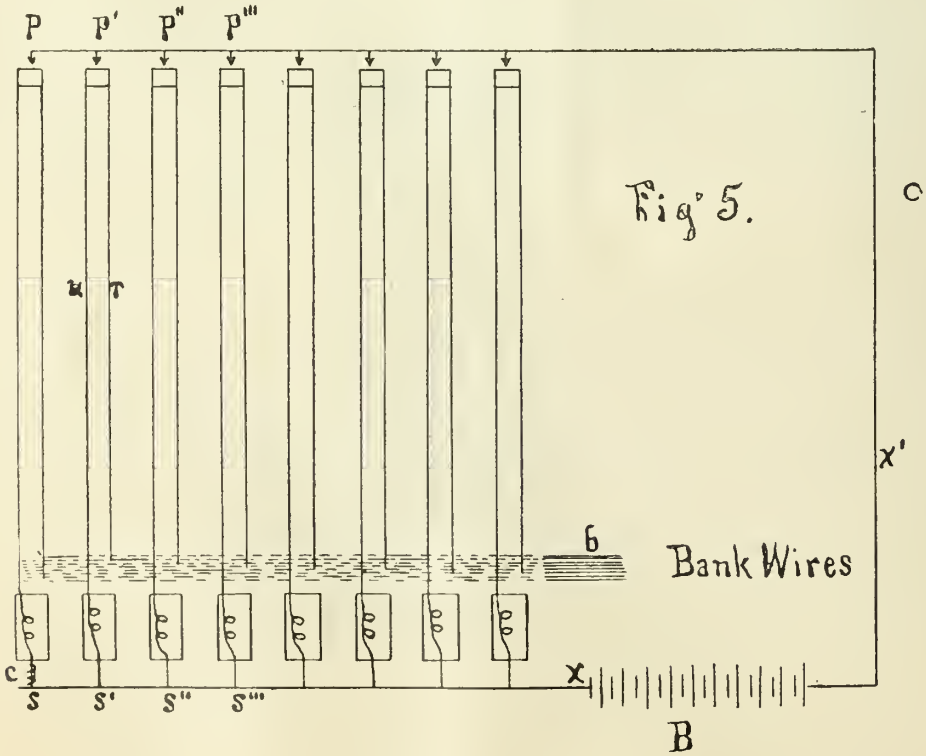




Fig' 3.

Fig. 4.





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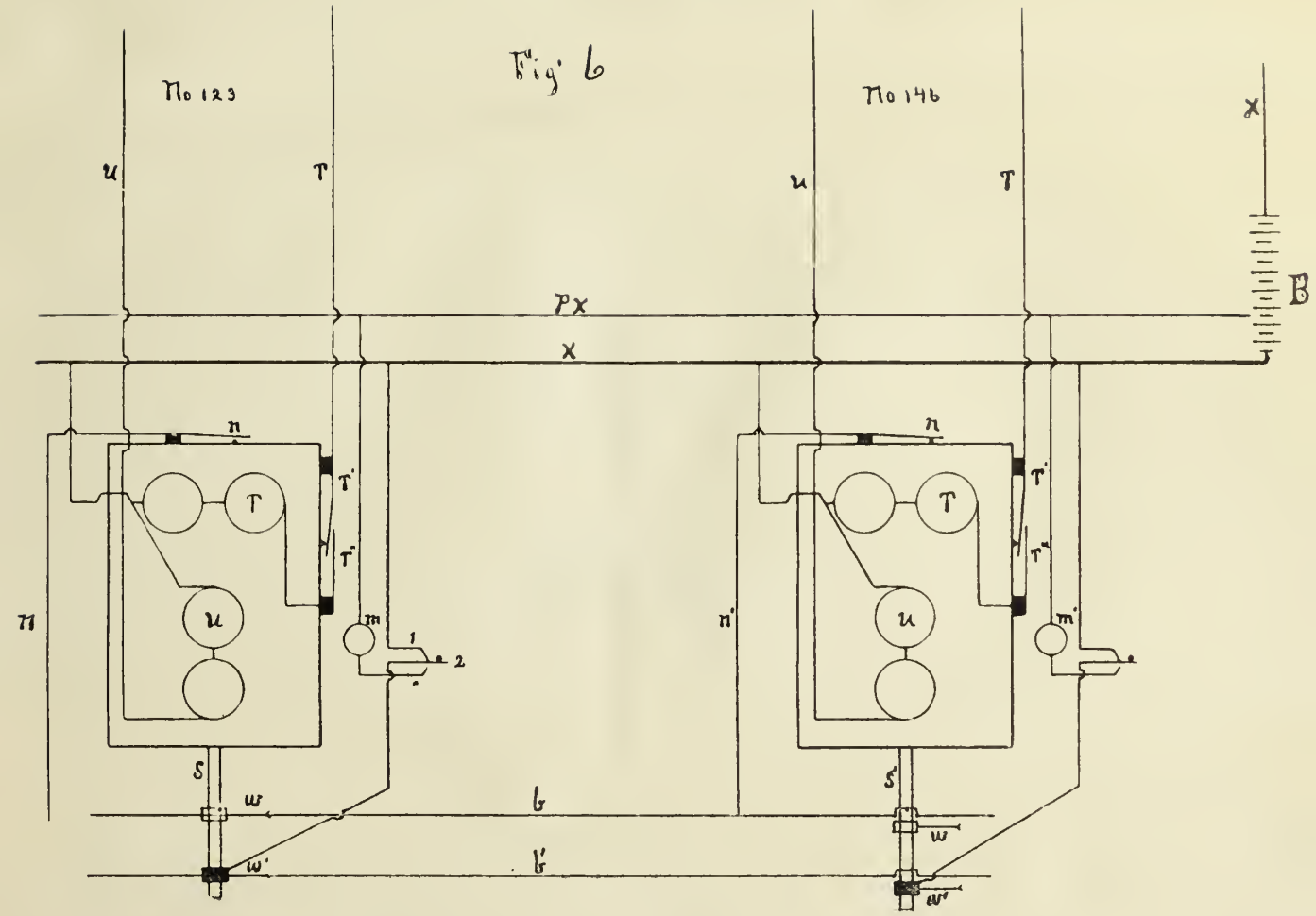
Fig 6
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No 146
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B
Px
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T'
T''
m
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2
S
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w'
b
b'
n'
m'
S'

Private Attachment

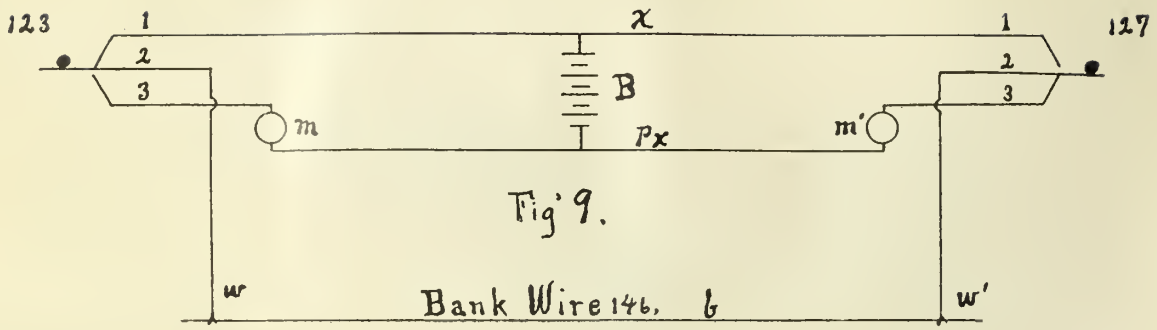
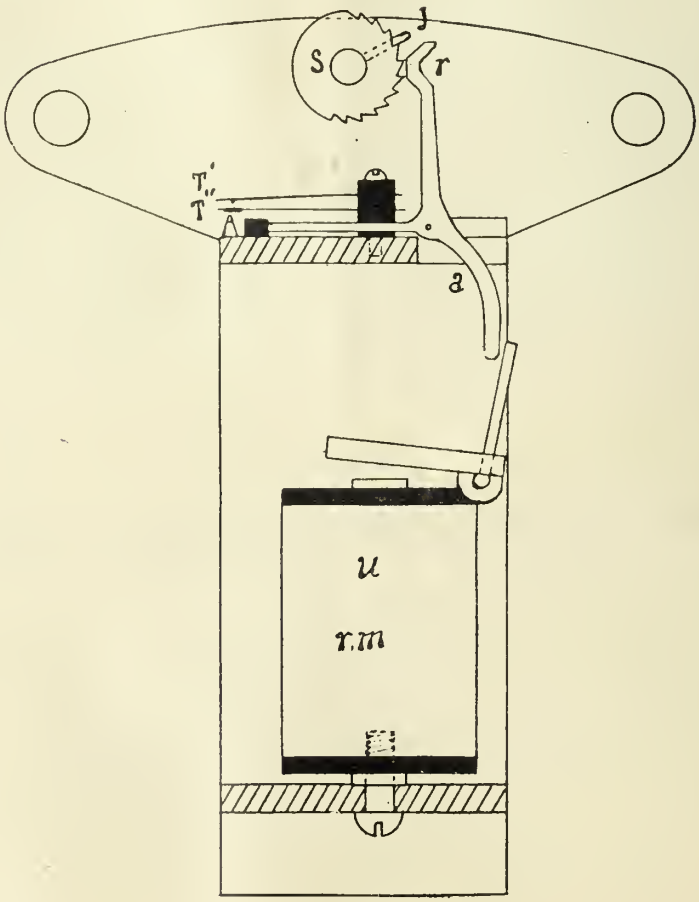


Fig 9.

Fig 7.



Release Mechanism

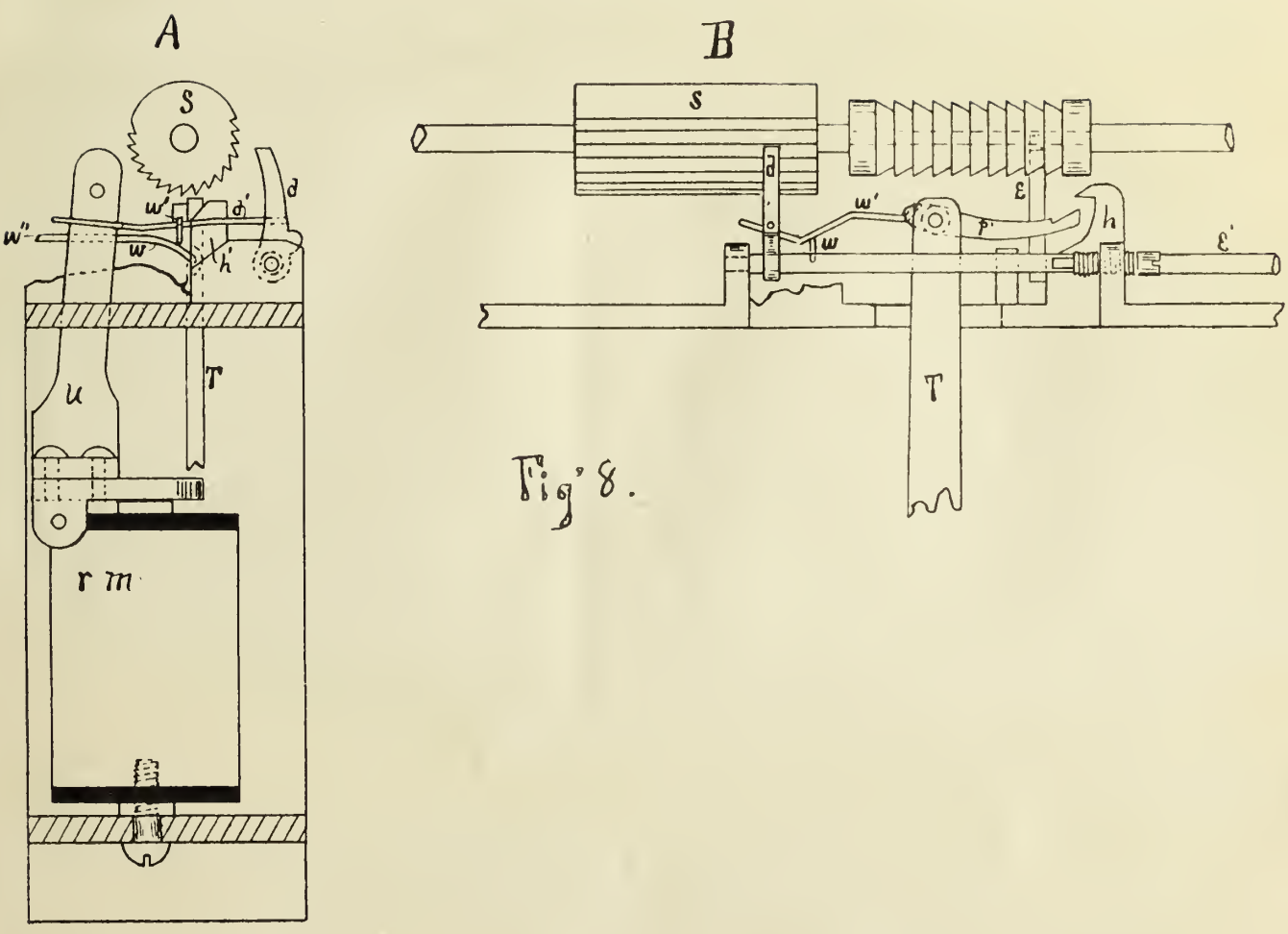
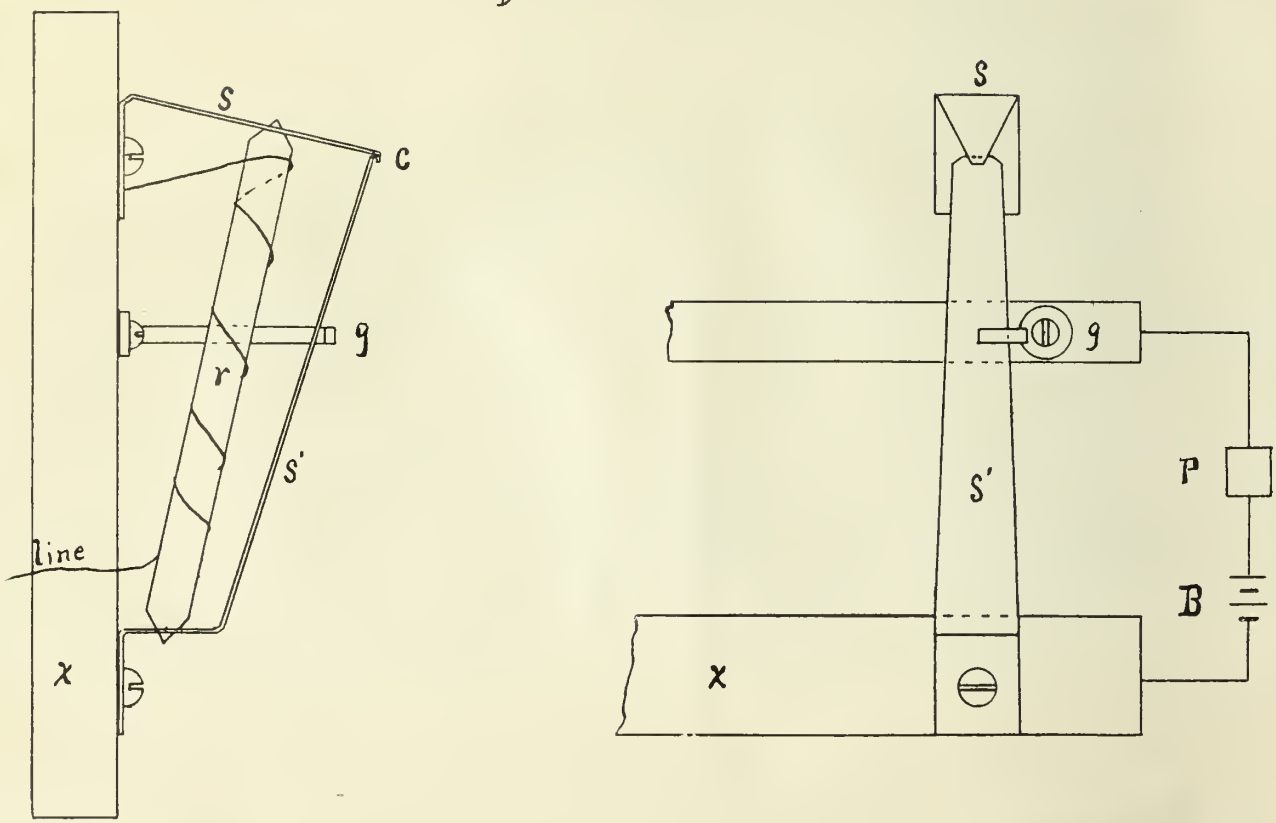
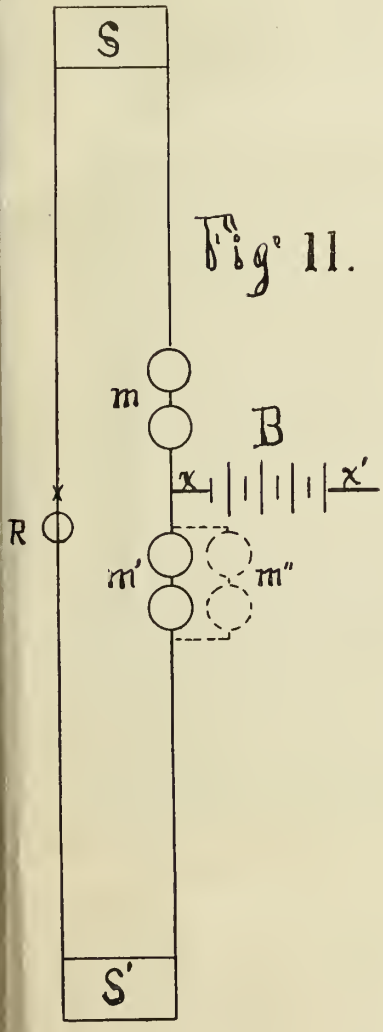


Fig. 8.

Fig. 10.



Talking Circuits,



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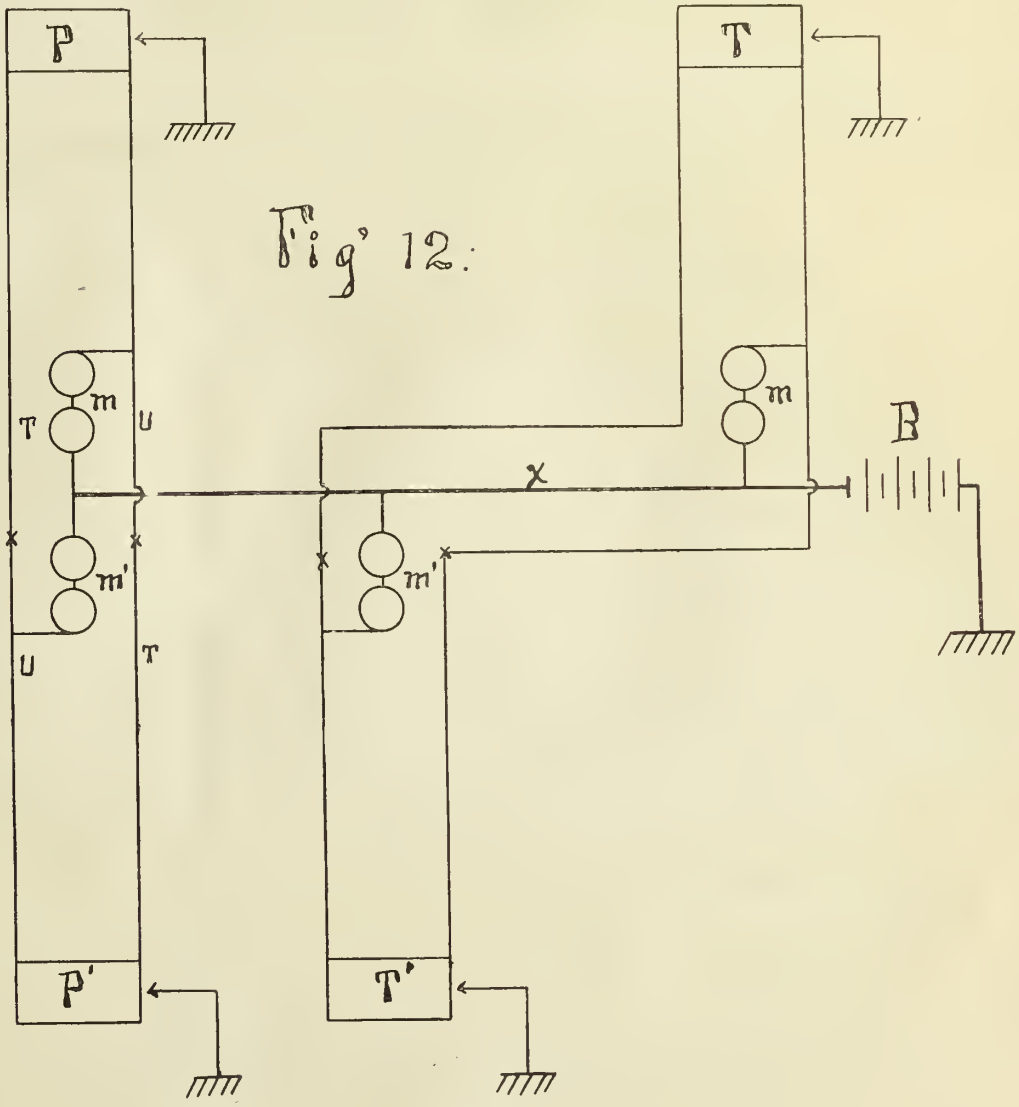
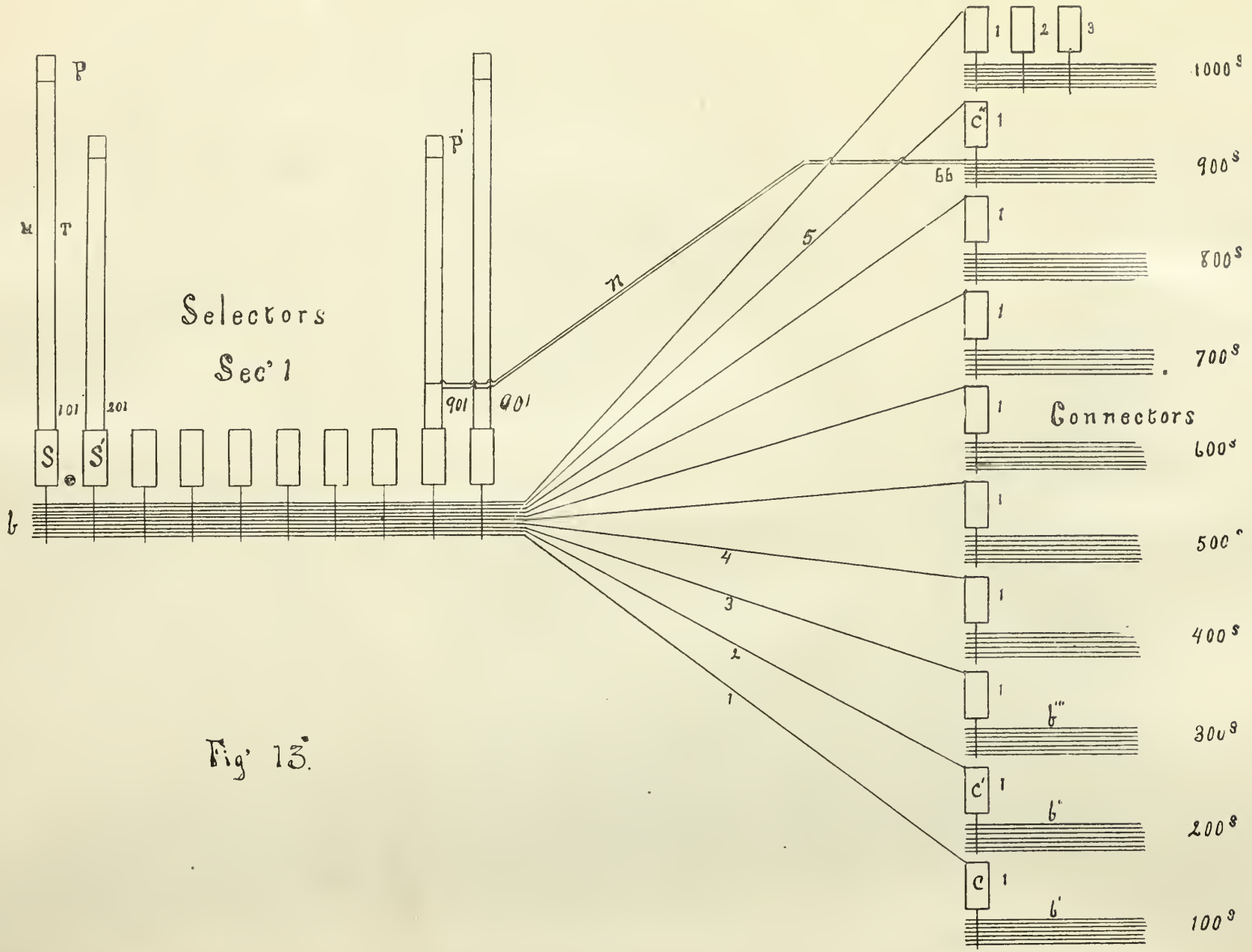


Fig. 12.


P
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Connectors
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1
400 s
1
b'''
300 s
C' 1
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C 1
b'
100 s

Fig' 13.

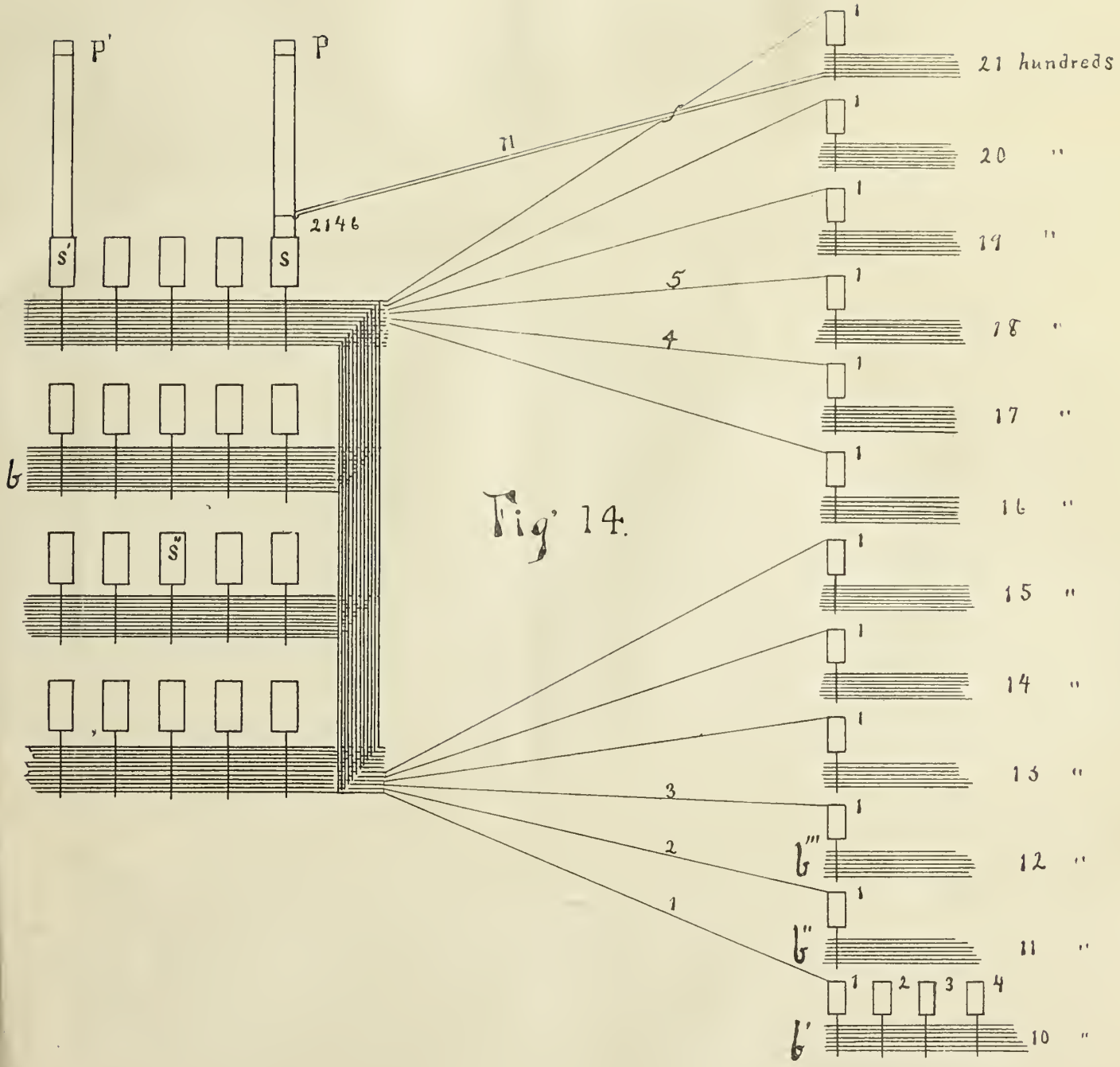
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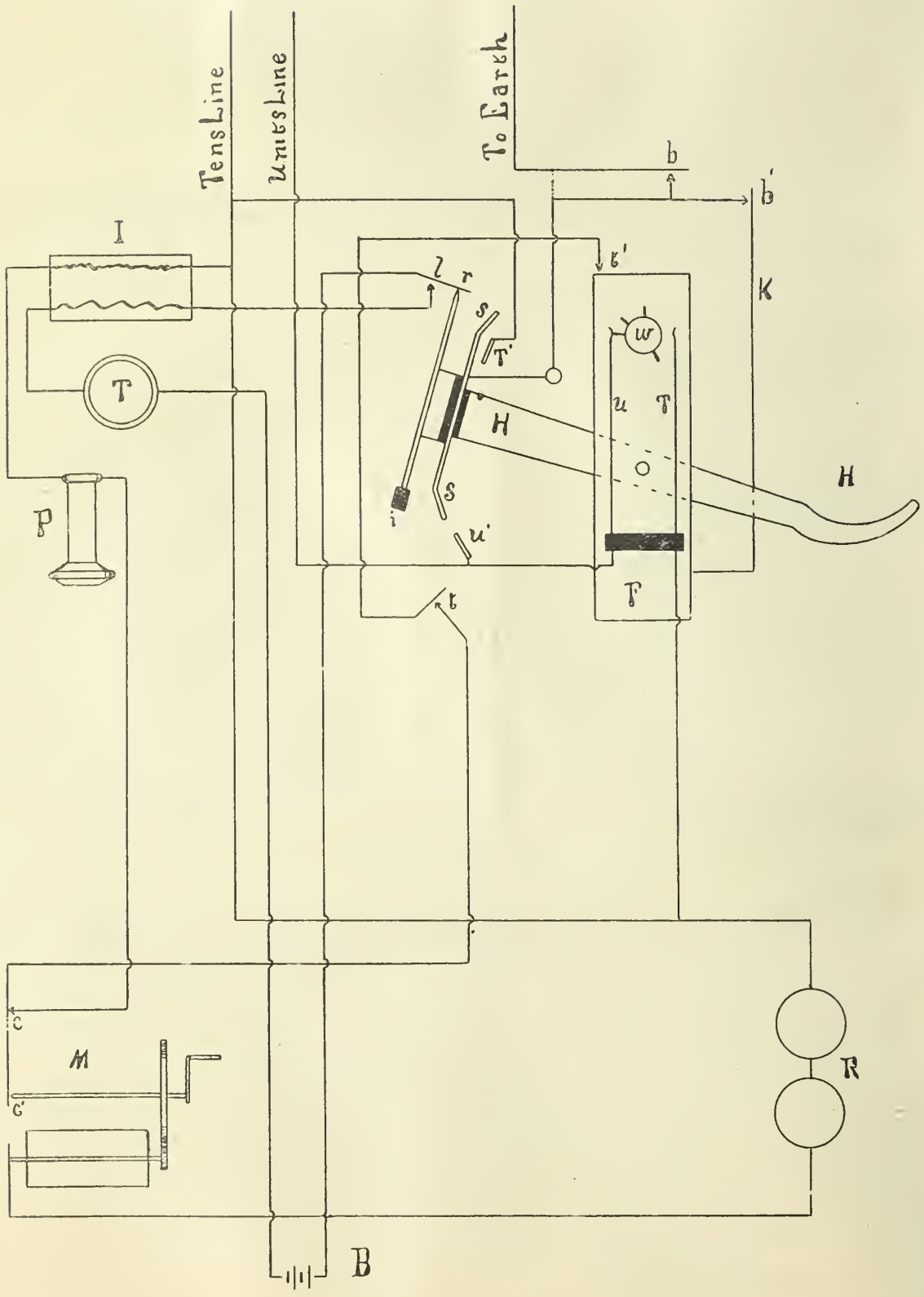
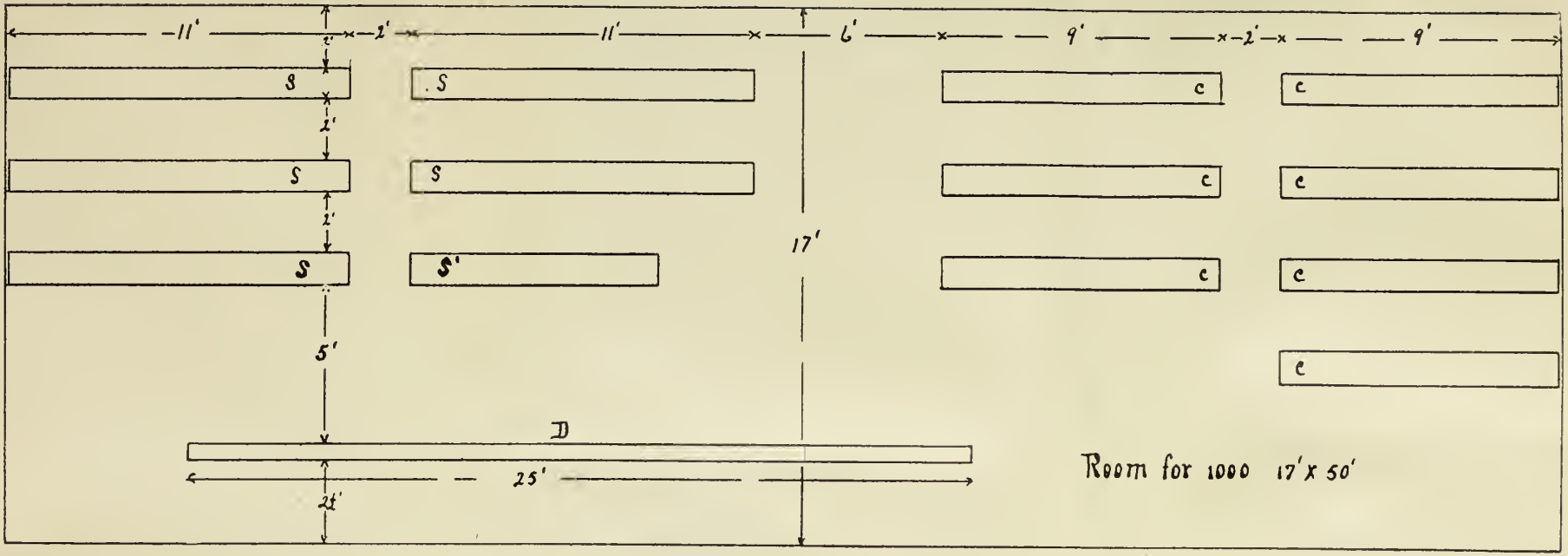
Fig. 14.

Fig 15.



Fig' 16.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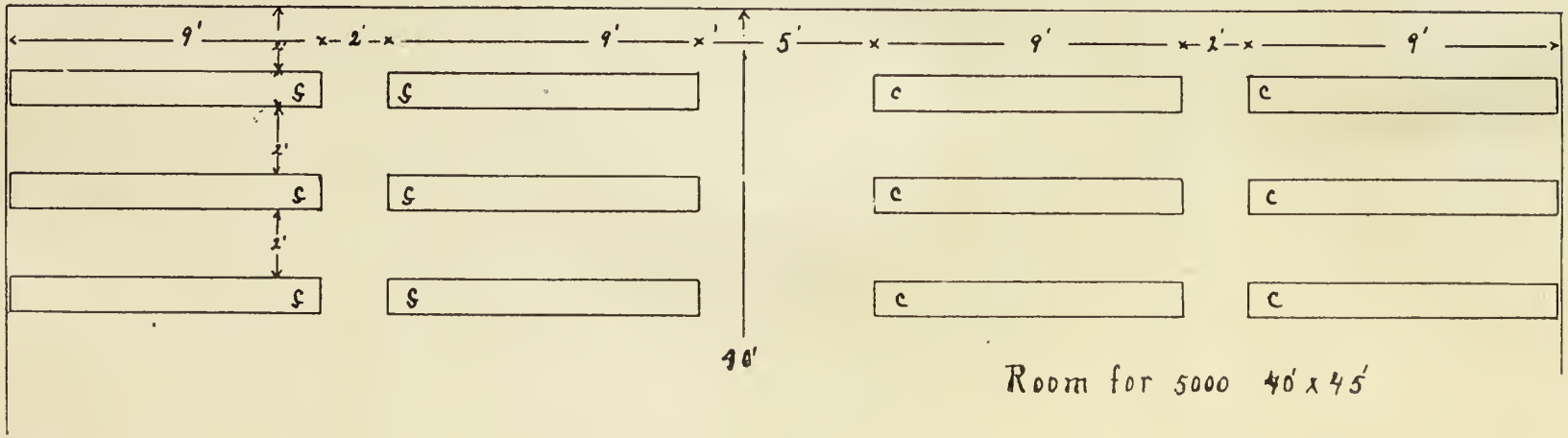
Room for 1000 17'x 50'

Fig 17.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1'
40'
Room for 5000 40'x 45'

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